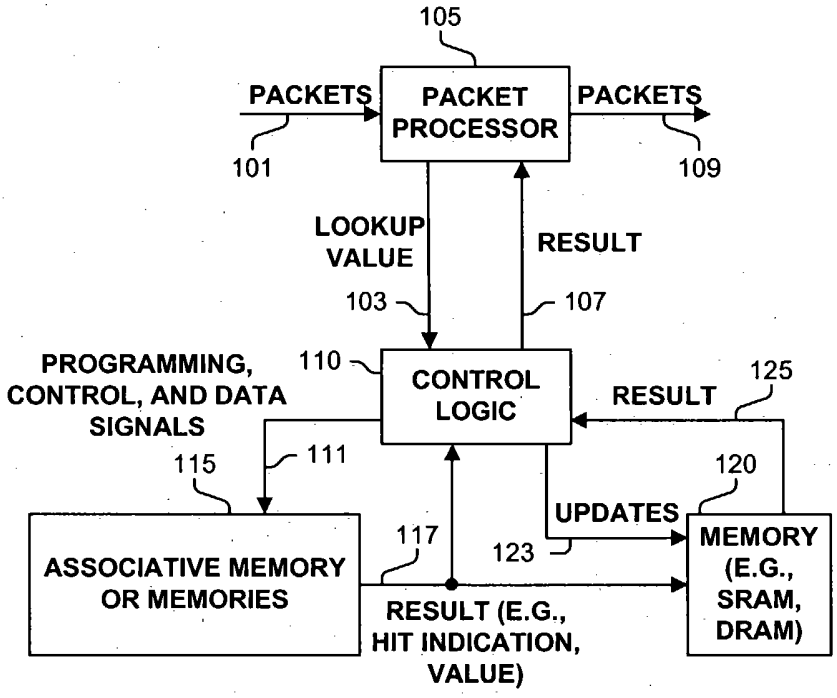

105
PACKETS
PACKET PROCESSOR
PACKETS
101
109
LOOKUP VALUE
RESULT
103
107
PROGRAMMING, CONTROL, AND DATA SIGNALS
110
CONTROL LOGIC
RESULT
125
115
111
120
UPDATES
ASSOCIATIVE MEMORY OR MEMORIES
117
123
MEMORY (E.G., SRAM, DRAM)
RESULT (E.G., HIT INDICATION, VALUE)

FIGURE 1A

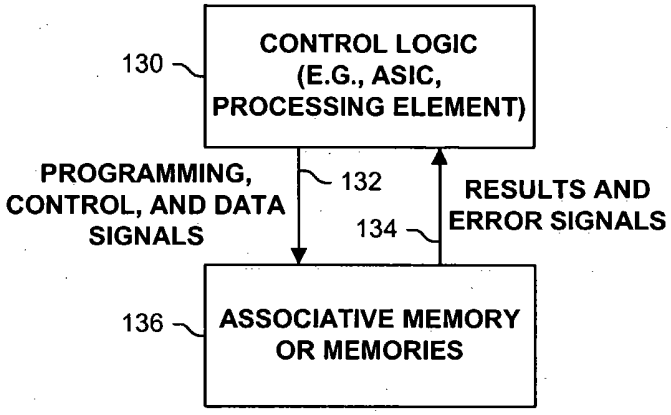


FIGURE 1B

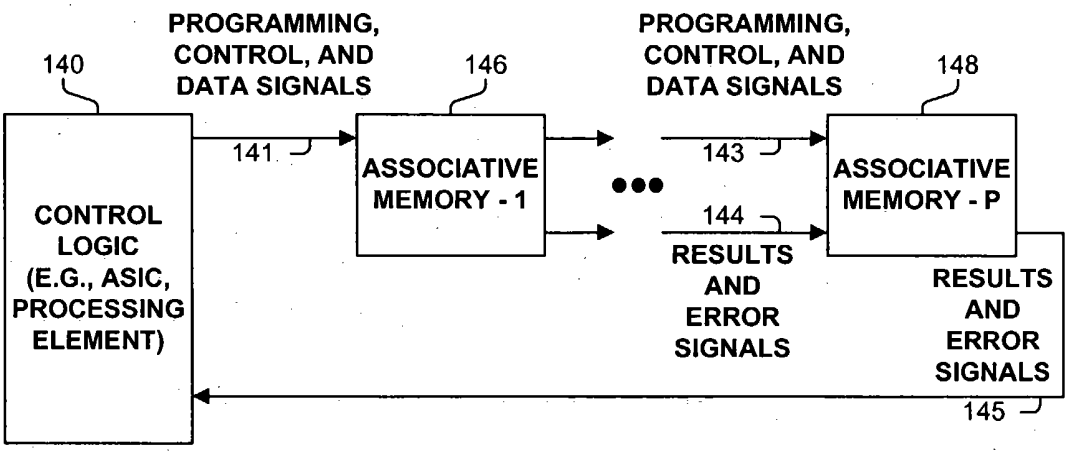


FIGURE 1C

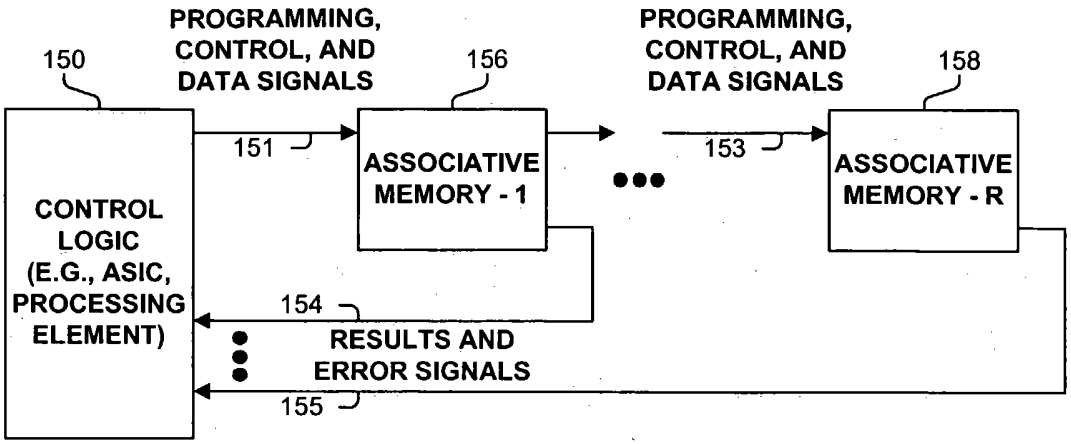


FIGURE 1D

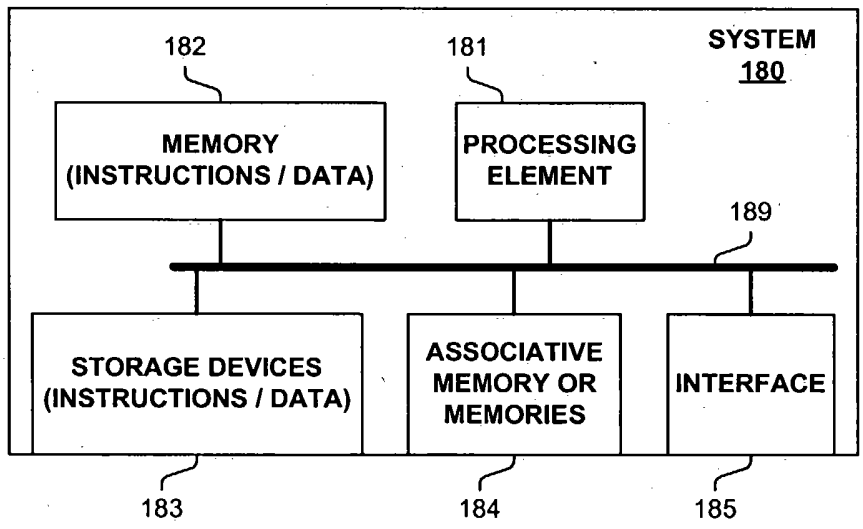


FIGURE 1E

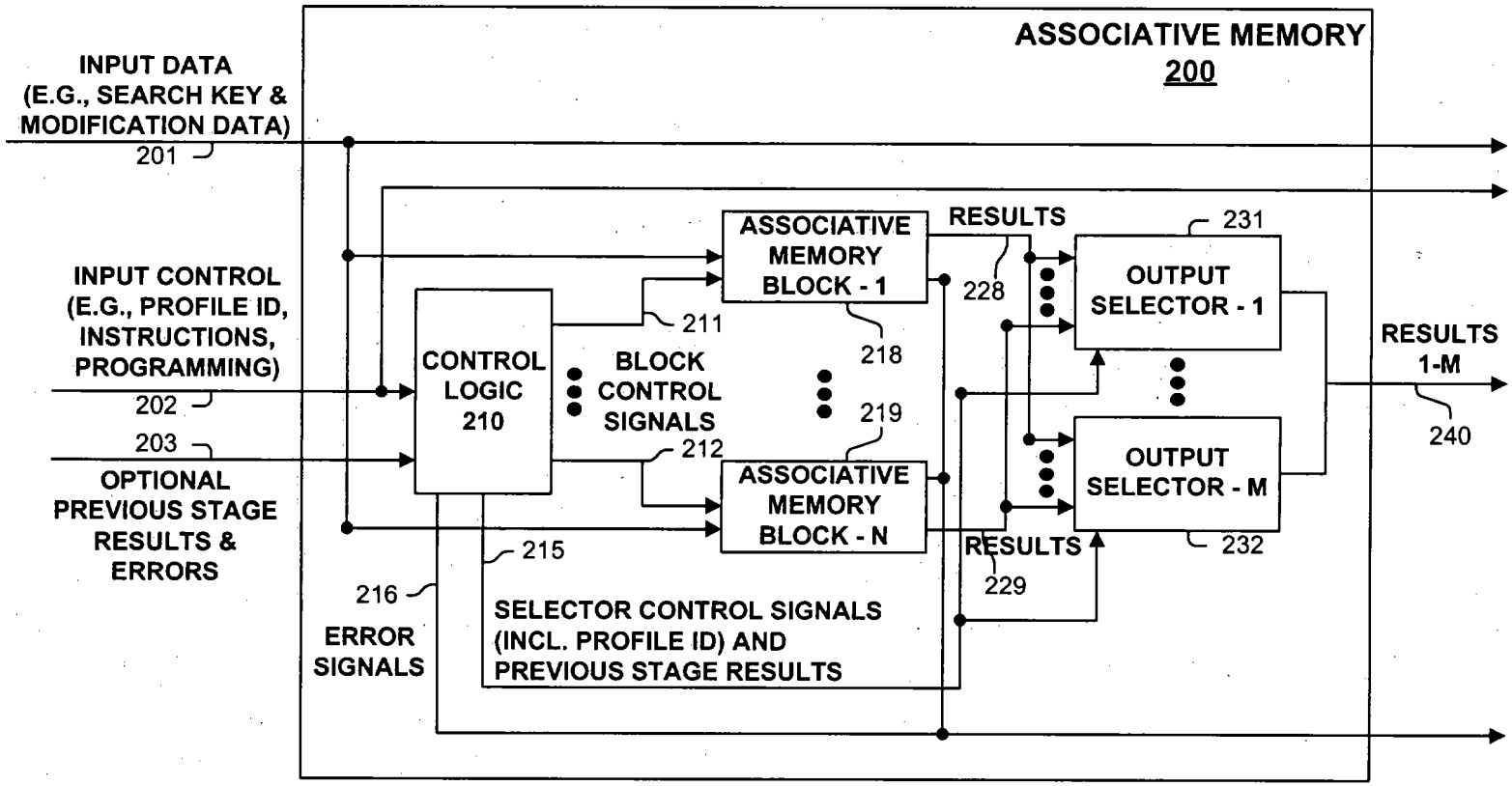

ASSOCIATIVE MEMORY
200
INPUT DATA
(E.G., SEARCH KEY &
MODIFICATION DATA)
201
INPUT CONTROL
(E.G., PROFILE ID,
INSTRUCTIONS,
PROGRAMMING)
202
203
OPTIONAL
PREVIOUS STAGE
RESULTS &
ERRORS
CONTROL
LOGIC
210
ASSOCIATIVE
MEMORY
BLOCK - 1
ASSOCIATIVE
MEMORY
BLOCK - N
211
212
BLOCK
CONTROL
SIGNALS
218
219
RESULTS
228
RESULTS
229
231
232
OUTPUT
SELECTOR - 1
OUTPUT
SELECTOR - M
RESULTS
1-M
240
215
216
ERROR
SIGNALS
SELECTOR CONTROL SIGNALS
(INCL. PROFILE ID) AND
PREVIOUS STAGE RESULTS

FIGURE 2

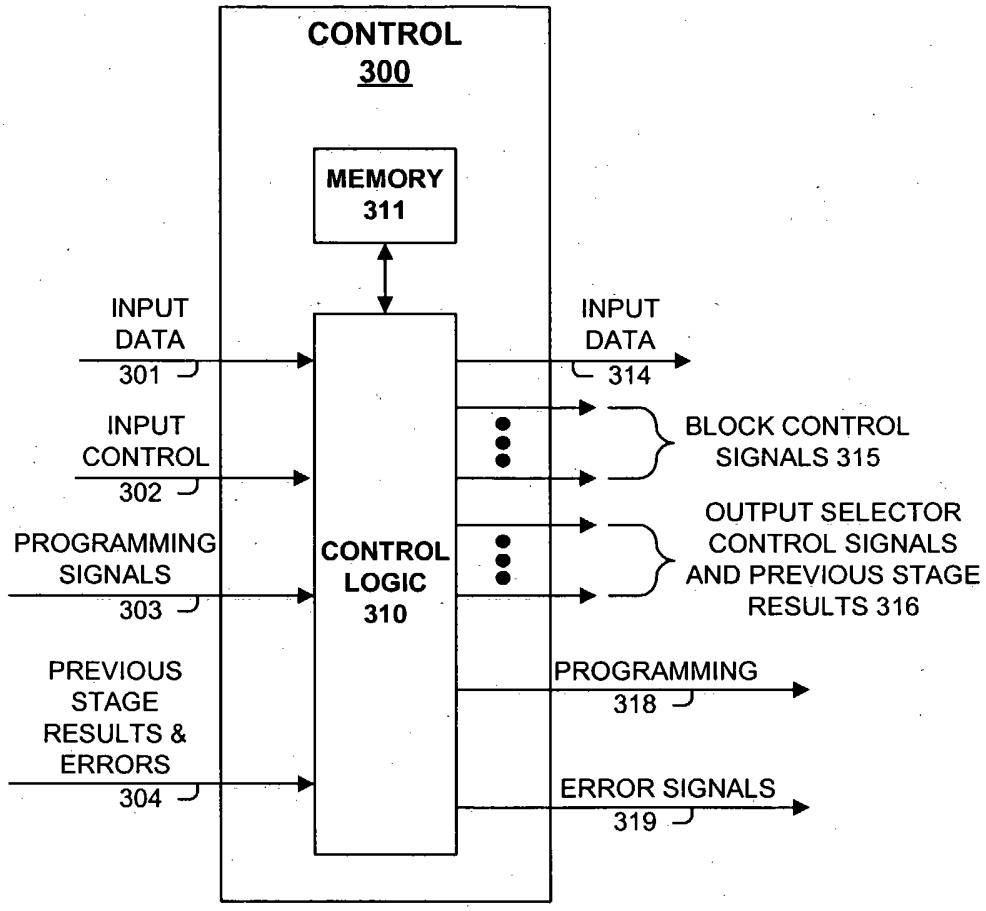

CONTROL
300
MEMORY
311
INPUT
DATA
301
INPUT
CONTROL
302
PROGRAMMING
SIGNALS
303
PREVIOUS
STAGE
RESULTS &
ERRORS
304
CONTROL
LOGIC
310
INPUT
DATA
314
BLOCK CONTROL
SIGNALS 315
OUTPUT SELECTOR
CONTROL SIGNALS
AND PREVIOUS STAGE
RESULTS 316
PROGRAMMING
318
ERROR SIGNALS
319

FIGURE 3A

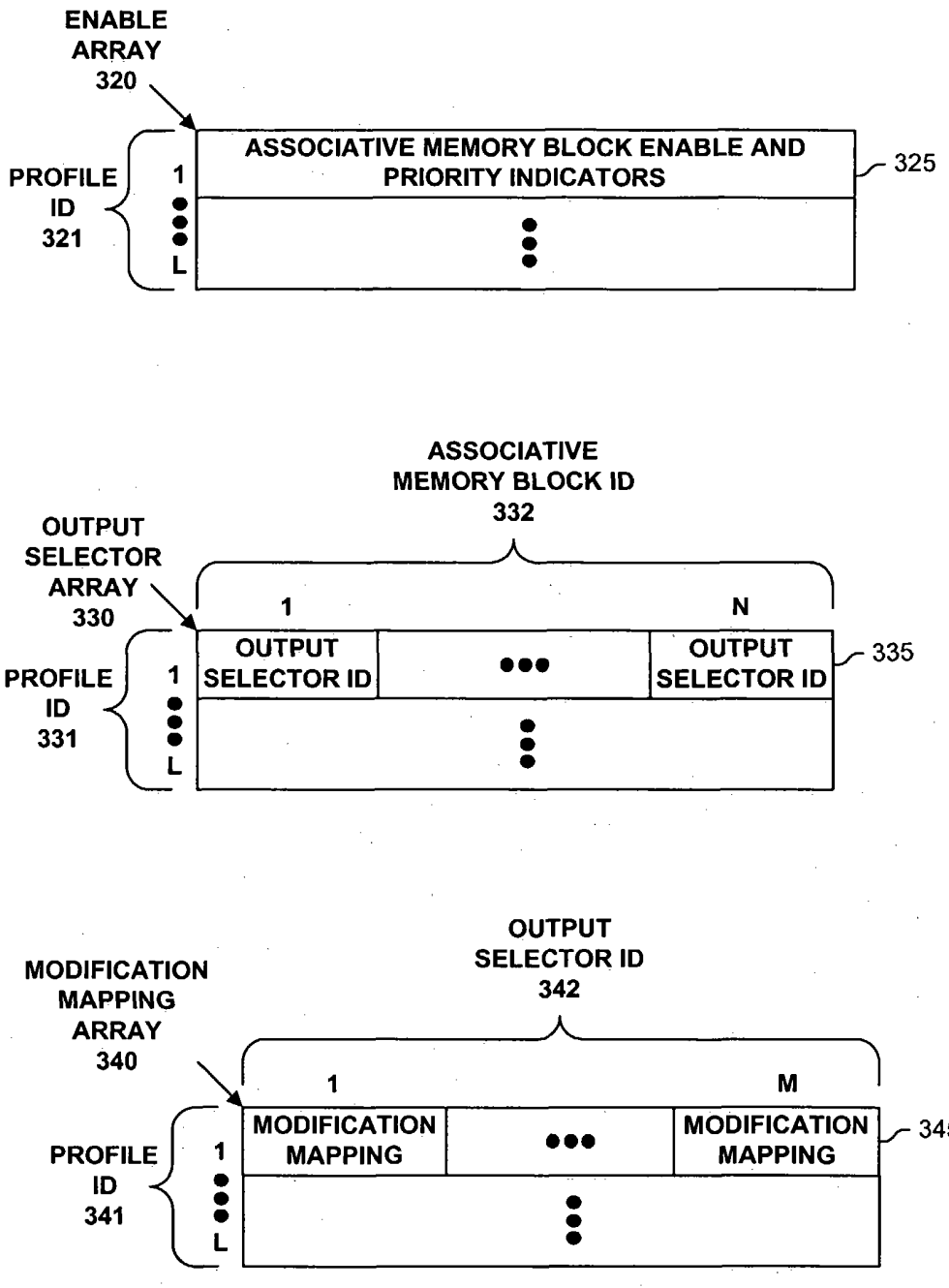

ENABLE ARRAY 320
PROFILE ID 321
1
L
ASSOCIATIVE MEMORY BLOCK ENABLE AND PRIORITY INDICATORS
325
ASSOCIATIVE MEMORY BLOCK ID 332
OUTPUT SELECTOR ARRAY 330
PROFILE ID 331
1
N
OUTPUT SELECTOR ID
OUTPUT SELECTOR ID
335
MODIFICATION MAPPING ARRAY 340
PROFILE ID 341
OUTPUT SELECTOR ID 342
1
M
MODIFICATION MAPPING
MODIFICATION MAPPING
345

FIGURE 3B

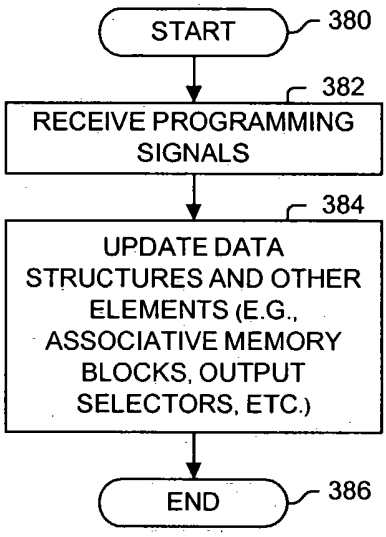

START
380
382
RECEIVE PROGRAMMING SIGNALS
384
UPDATE DATA STRUCTURES AND OTHER ELEMENTS (E.G., ASSOCIATIVE MEMORY BLOCKS, OUTPUT SELECTORS, ETC.)
END
386

FIGURE 3C

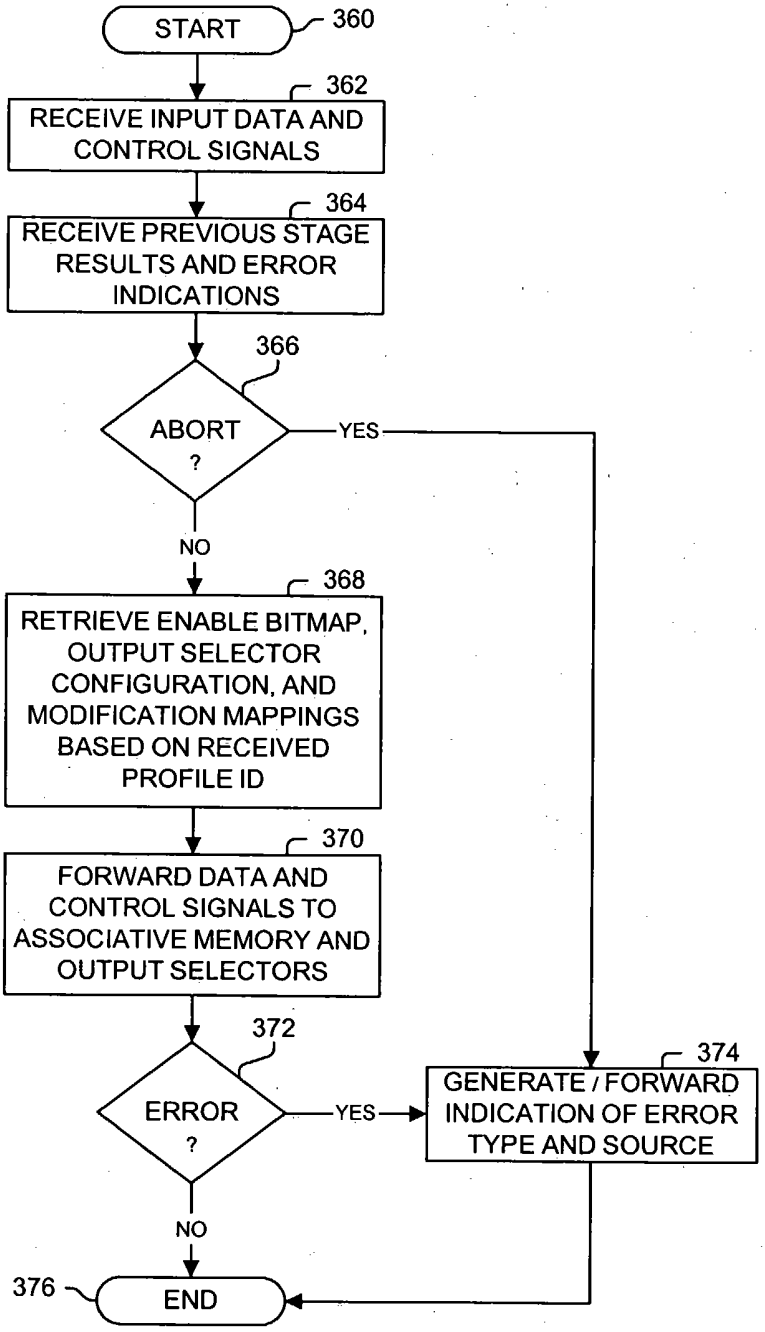

START
360
362
RECEIVE INPUT DATA AND CONTROL SIGNALS
364
RECEIVE PREVIOUS STAGE RESULTS AND ERROR INDICATIONS
366
ABORT ?
YES
NO
368
RETRIEVE ENABLE BITMAP, OUTPUT SELECTOR CONFIGURATION, AND MODIFICATION MAPPINGS BASED ON RECEIVED PROFILE ID
370
FORWARD DATA AND CONTROL SIGNALS TO ASSOCIATIVE MEMORY AND OUTPUT SELECTORS
372
ERROR ?
YES
374
GENERATE / FORWARD INDICATION OF ERROR TYPE AND SOURCE
NO
376
END

FIGURE 3D

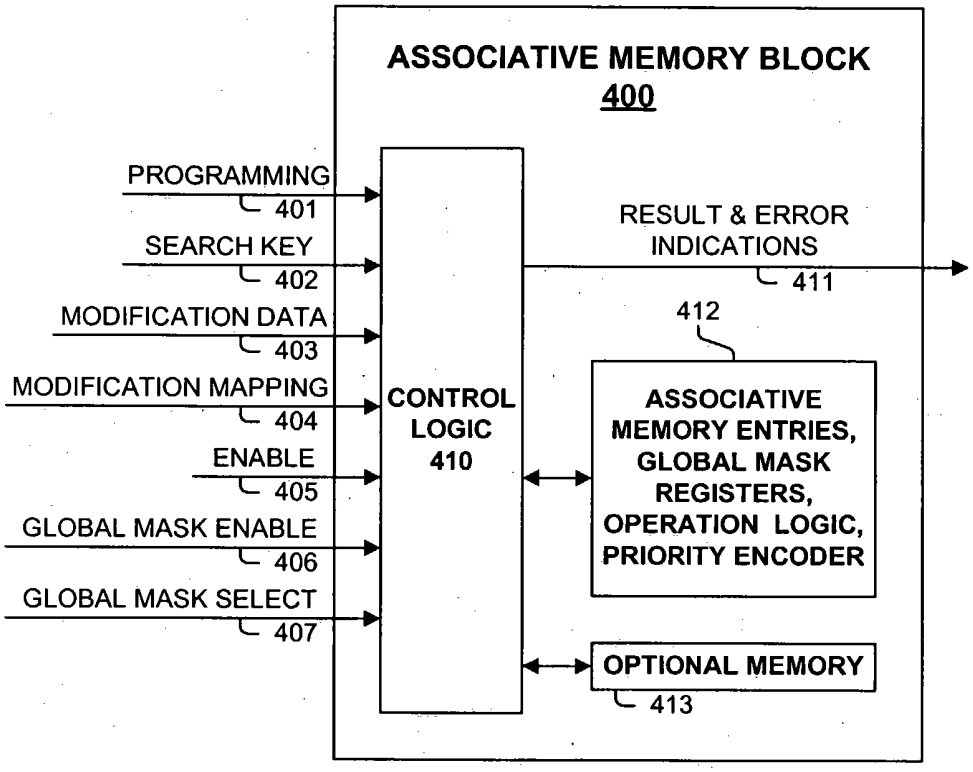

ASSOCIATIVE MEMORY BLOCK
400
PROGRAMMING
401
SEARCH KEY
402
MODIFICATION DATA
403
MODIFICATION MAPPING
404
ENABLE
405
GLOBAL MASK ENABLE
406
GLOBAL MASK SELECT
407
CONTROL LOGIC 410
RESULT & ERROR INDICATIONS
411
412
ASSOCIATIVE MEMORY ENTRIES, GLOBAL MASK REGISTERS, OPERATION LOGIC, PRIORITY ENCODER
OPTIONAL MEMORY
413

FIGURE 4A

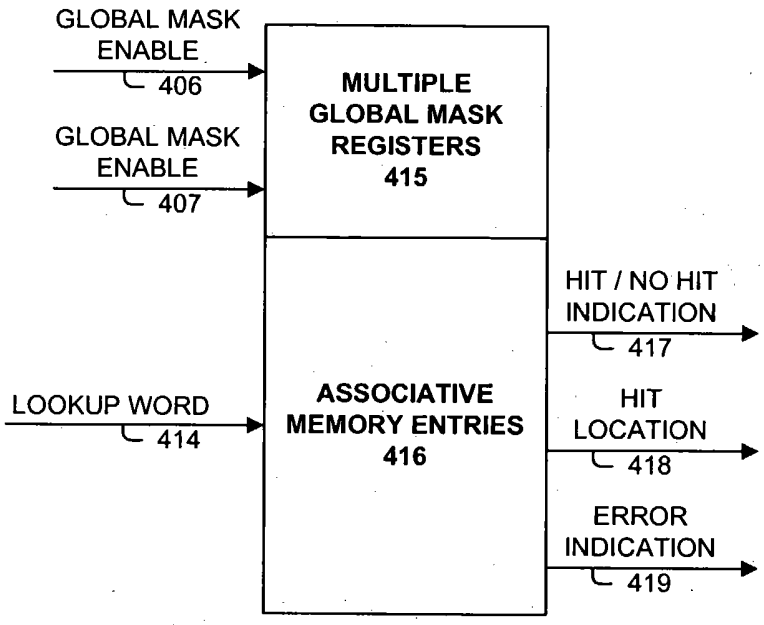


FIGURE 4B

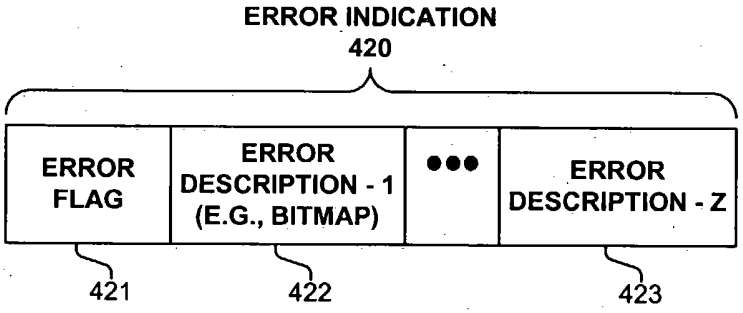


FIGURE 4C

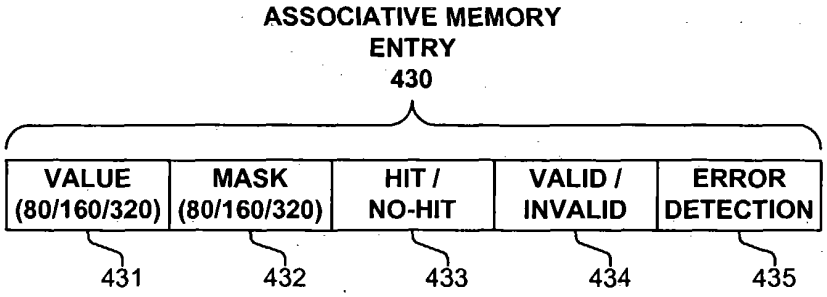


FIGURE 4D

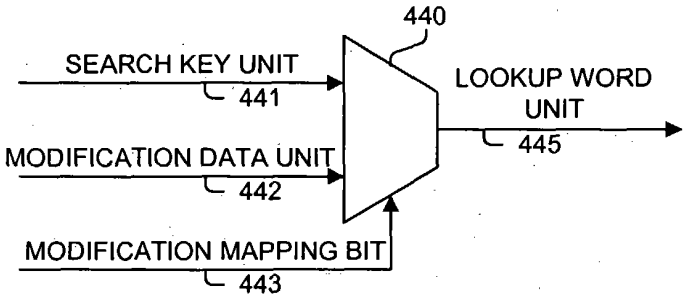


FIGURE 4E

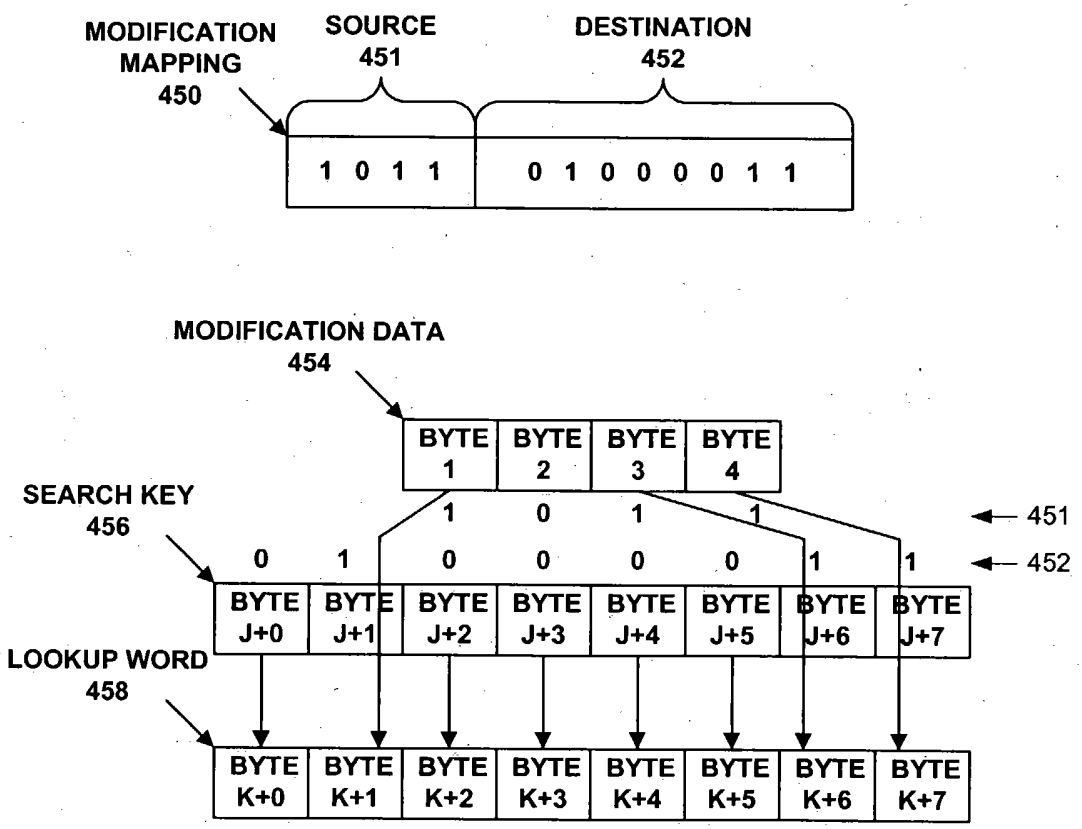

MODIFICATION MAPPING 450
SOURCE 451
DESTINATION 452
1 0 1 1
0 1 0 0 0 0 1 1
MODIFICATION DATA 454
BYTE 1
BYTE 2
BYTE 3
BYTE 4
SEARCH KEY 456
1 0 1 1
451
0 1 0 0 0 0 1 1
452
BYTE J+0
BYTE J+1
BYTE J+2
BYTE J+3
BYTE J+4
BYTE J+5
BYTE J+6
BYTE J+7
LOOKUP WORD 458
BYTE K+0
BYTE K+1
BYTE K+2
BYTE K+3
BYTE K+4
BYTE K+5
BYTE K+6
BYTE K+7

FIGURE 4F

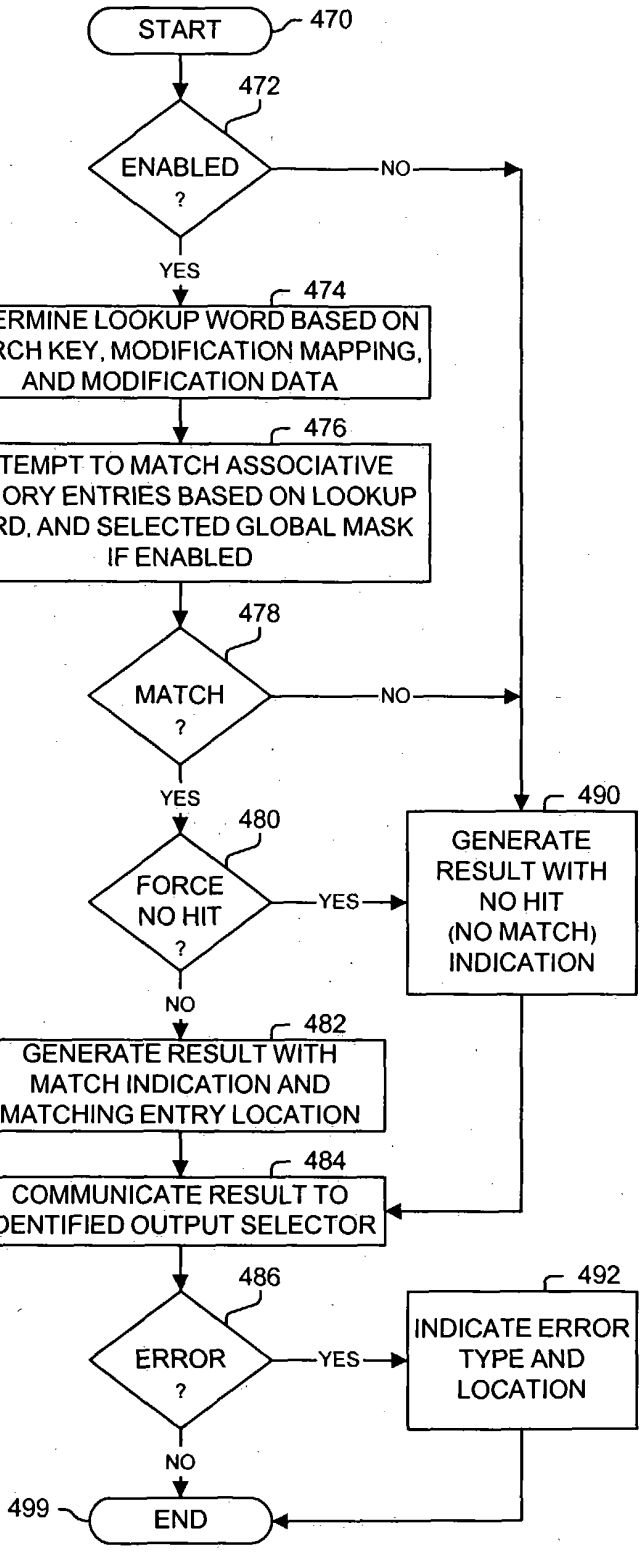

START
470
472
ENABLED ?
NO
YES
474
DETERMINE LOOKUP WORD BASED ON SEARCH KEY, MODIFICATION MAPPING, AND MODIFICATION DATA
476
ATTEMPT TO MATCH ASSOCIATIVE MEMORY ENTRIES BASED ON LOOKUP WORD, AND SELECTED GLOBAL MASK IF ENABLED
478
MATCH ?
NO
YES
490
480
FORCE NO HIT ?
YES
GENERATE RESULT WITH NO HIT (NO MATCH) INDICATION
NO
482
GENERATE RESULT WITH MATCH INDICATION AND MATCHING ENTRY LOCATION
484
COMMUNICATE RESULT TO IDENTIFIED OUTPUT SELECTOR
486
492
ERROR ?
YES
INDICATE ERROR TYPE AND LOCATION
NO
499
END

FIGURE 4G

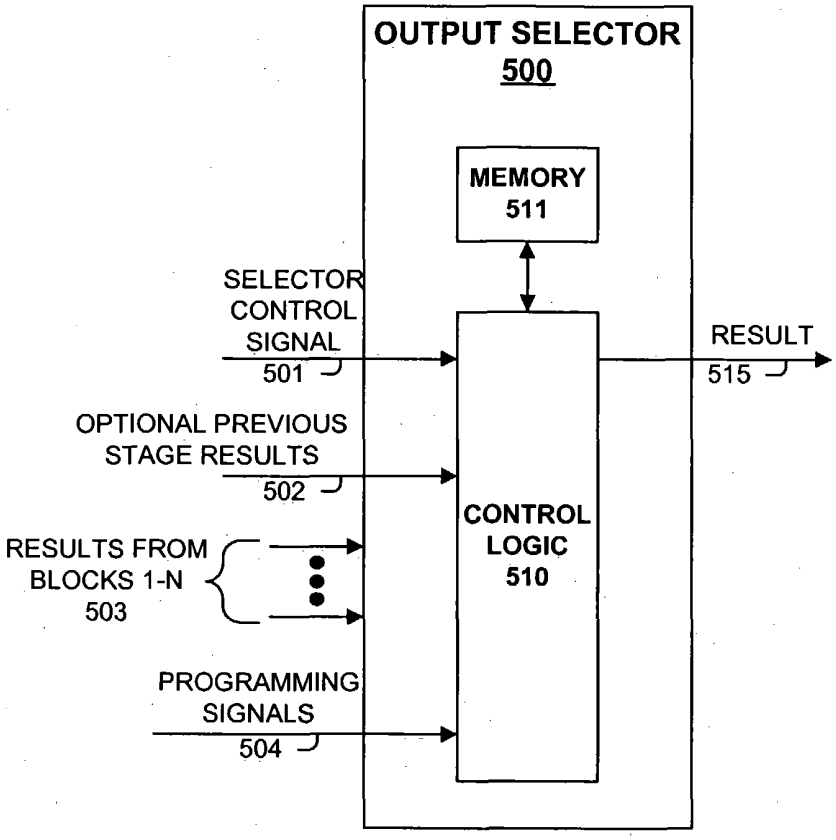


FIGURE 5A

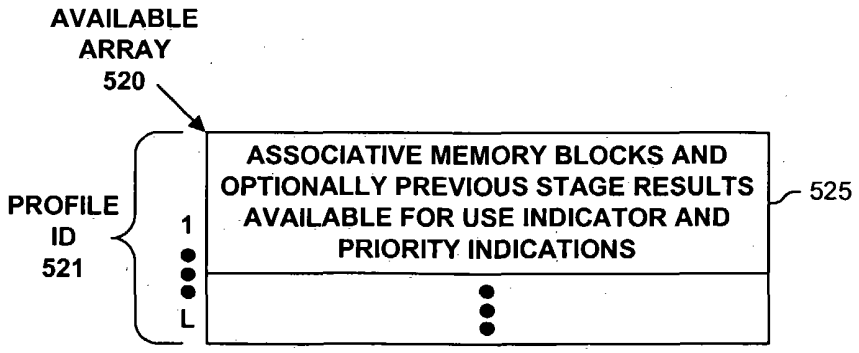


FIGURE 5B

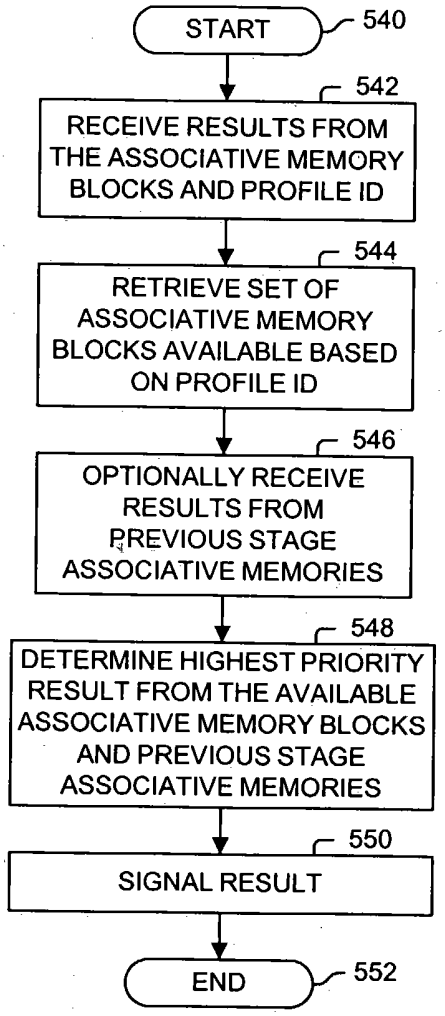

START
540
542
RECEIVE RESULTS FROM THE ASSOCIATIVE MEMORY BLOCKS AND PROFILE ID
544
RETRIEVE SET OF ASSOCIATIVE MEMORY BLOCKS AVAILABLE BASED ON PROFILE ID
546
OPTIONALLY RECEIVE RESULTS FROM PREVIOUS STAGE ASSOCIATIVE MEMORIES
548
DETERMINE HIGHEST PRIORITY RESULT FROM THE AVAILABLE ASSOCIATIVE MEMORY BLOCKS AND PREVIOUS STAGE ASSOCIATIVE MEMORIES
550
SIGNAL RESULT
END
552

FIGURE 5C

POLICY MAP
600

```
route-map my_map sequence_1
match ip address ACL101
set ip next-hop 192.10.10.1

route-map my_map sequence_2
match ip address ACL102
set ip next-hop 198.20.20.1

ip access-list ACL101 deny ip 10.0.0.0 0.255.255.255 any
ip access-list ACL101 permit ip any any

ip access-list ACL102 permit ip any 20.0.0.0 0.255.255.255
ip access-list ACL102 deny ip any any

int f3/1
ip policy route-map my_map
```

FIGURE 6A

BLOCK/
ASSOCIATIVE
MEMORY 1
ENTRIES
621

```
10.*.*.*    *.*.*.*   FORCE NO-HIT = 1  PRIORITY = 1
 *.*.*.*    *.*.*.*   FORCE NO-HIT = 0  PRIORITY = 1
```

```
 *.*.*.*   20.*.*.*   FORCE NO-HIT= 0  PRIORITY = 2
 *.*.*.*    *.*.*.*   FORCE NO-HIT= 1  PRIORITY = 2
```

BLOCK/
ASSOCIATIVE
MEMORY 2
ENTRIES
622

FIGURE 6B

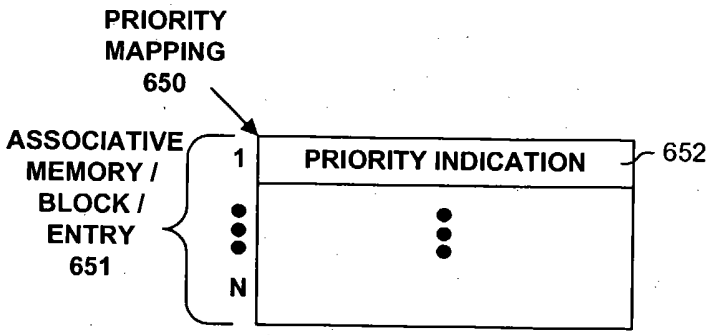

PRIORITY
MAPPING
650
ASSOCIATIVE
MEMORY /
BLOCK /
ENTRY
651
1
N
PRIORITY INDICATION
652

FIGURE 6C

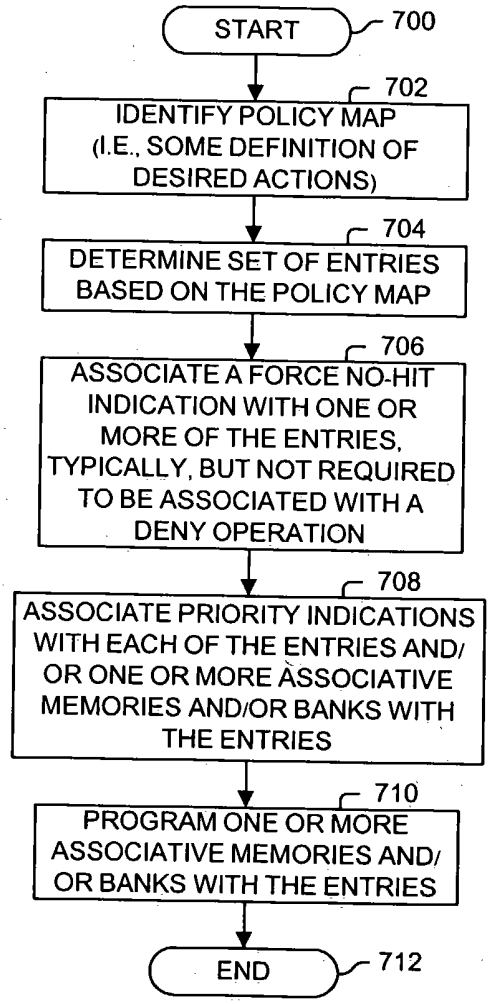

START
700
IDENTIFY POLICY MAP (I.E., SOME DEFINITION OF DESIRED ACTIONS)
702
DETERMINE SET OF ENTRIES BASED ON THE POLICY MAP
704
ASSOCIATE A FORCE NO-HIT INDICATION WITH ONE OR MORE OF THE ENTRIES, TYPICALLY, BUT NOT REQUIRED TO BE ASSOCIATED WITH A DENY OPERATION
706
ASSOCIATE PRIORITY INDICATIONS WITH EACH OF THE ENTRIES AND/ OR ONE OR MORE ASSOCIATIVE MEMORIES AND/OR BANKS WITH THE ENTRIES
708
PROGRAM ONE OR MORE ASSOCIATIVE MEMORIES AND/ OR BANKS WITH THE ENTRIES
710
END
712

FIGURE 7A

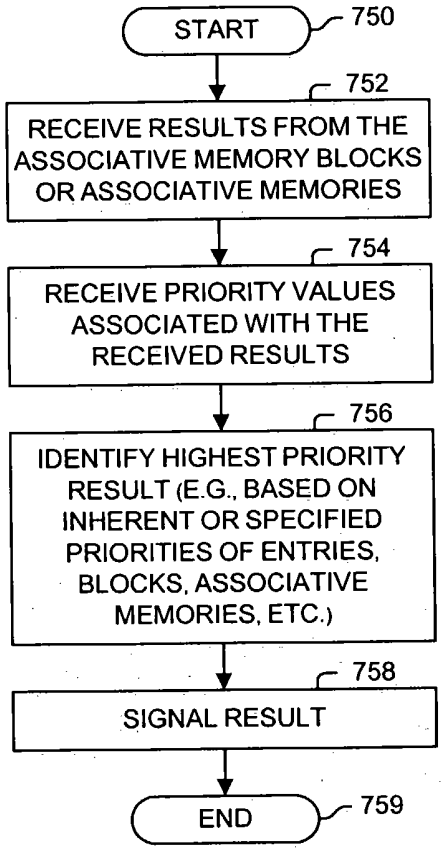

START
750
752
RECEIVE RESULTS FROM THE ASSOCIATIVE MEMORY BLOCKS OR ASSOCIATIVE MEMORIES
754
RECEIVE PRIORITY VALUES ASSOCIATED WITH THE RECEIVED RESULTS
756
IDENTIFY HIGHEST PRIORITY RESULT (E.G., BASED ON INHERENT OR SPECIFIED PRIORITIES OF ENTRIES, BLOCKS, ASSOCIATIVE MEMORIES, ETC.)
758
SIGNAL RESULT
END
759

FIGURE 7B

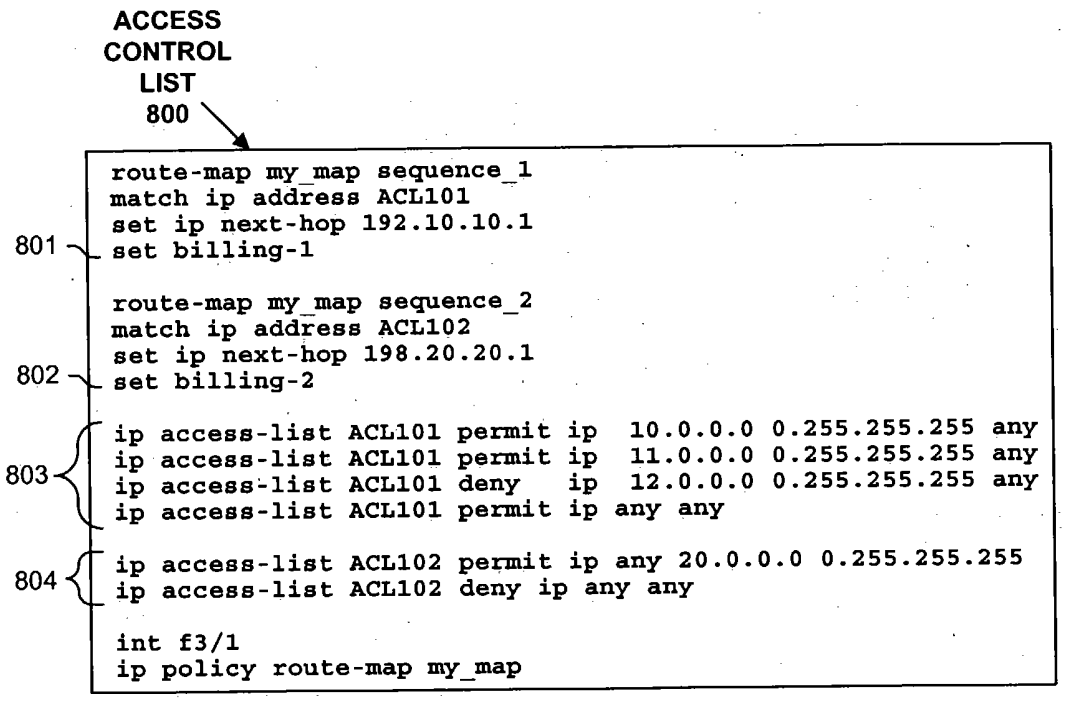

ACCESS
CONTROL
LIST
800
route-map my_map sequence_1
match ip address ACL101
set ip next-hop 192.10.10.1
801
set billing-1
route-map my_map sequence_2
match ip address ACL102
set ip next-hop 198.20.20.1
802
set billing-2
ip access-list ACL101 permit ip 10.0.0.0 0.255.255.255 any
ip access-list ACL101 permit ip 11.0.0.0 0.255.255.255 any
803
ip access-list ACL101 deny ip 12.0.0.0 0.255.255.255 any
ip access-list ACL101 permit ip any any
ip access-list ACL102 permit ip any 20.0.0.0 0.255.255.255
804
ip access-list ACL102 deny ip any any
int f3/1
ip policy route-map my_map

FIGURE 8A

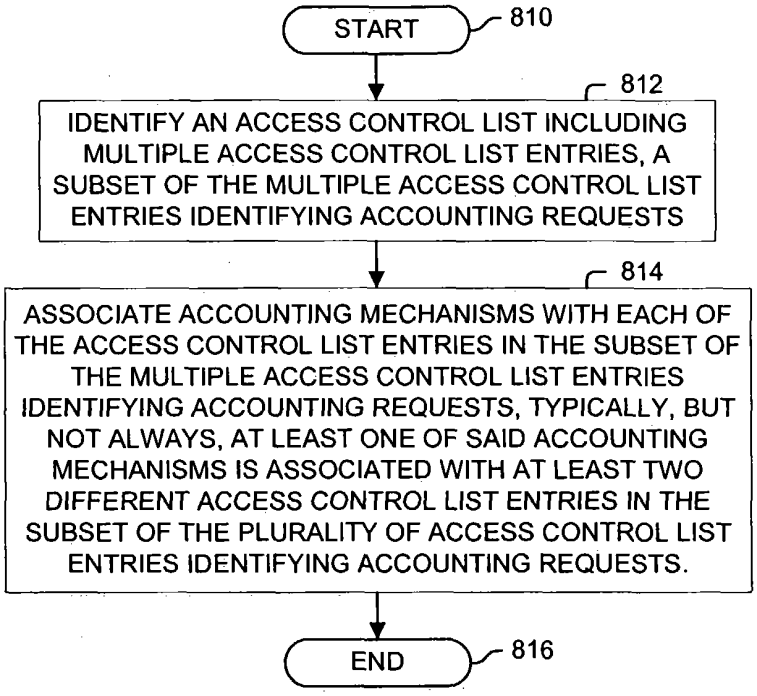


FIGURE 8B

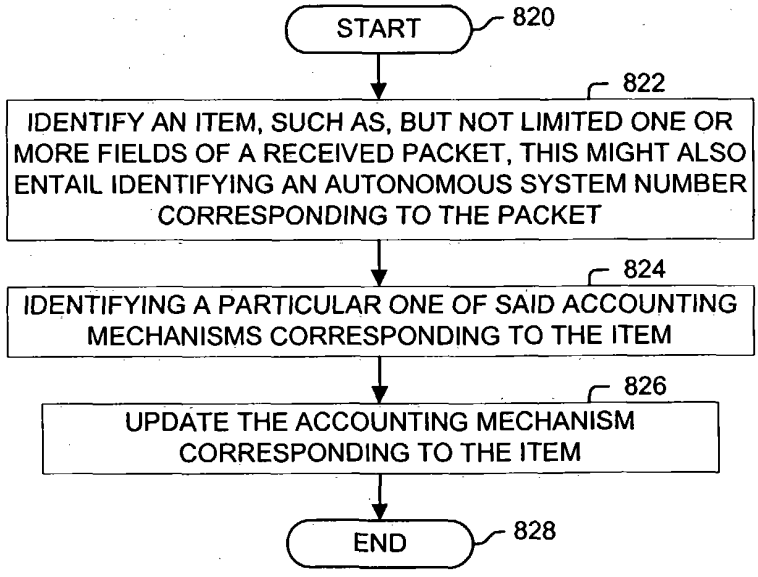


FIGURE 8C

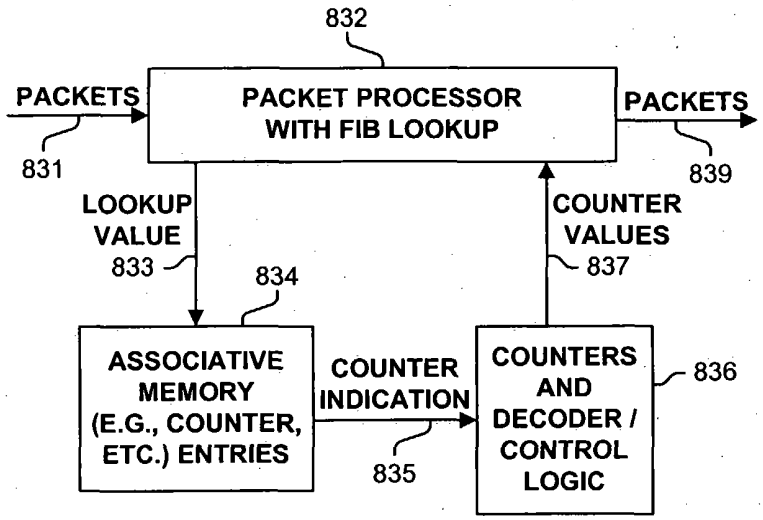


FIGURE 8D

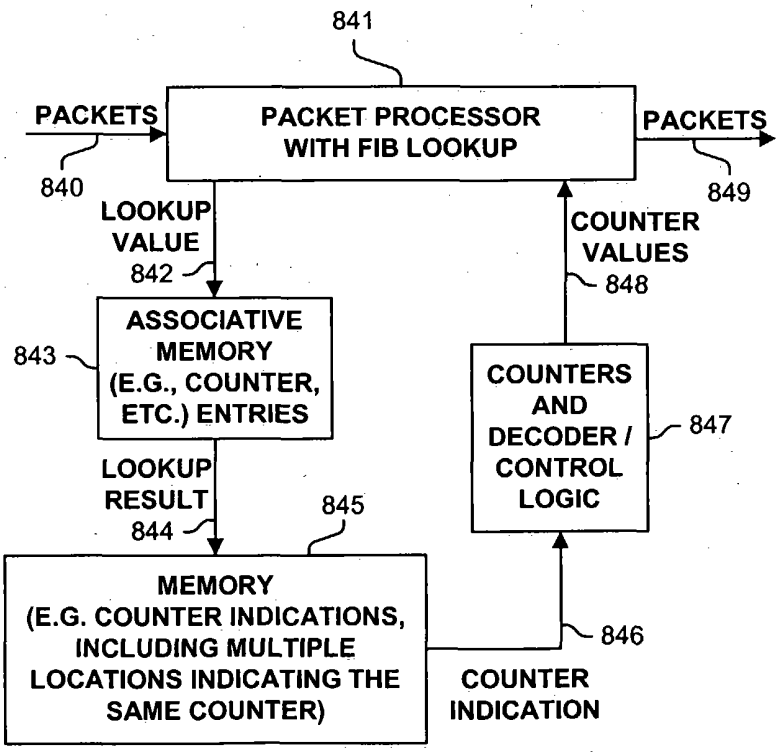


FIGURE 8E

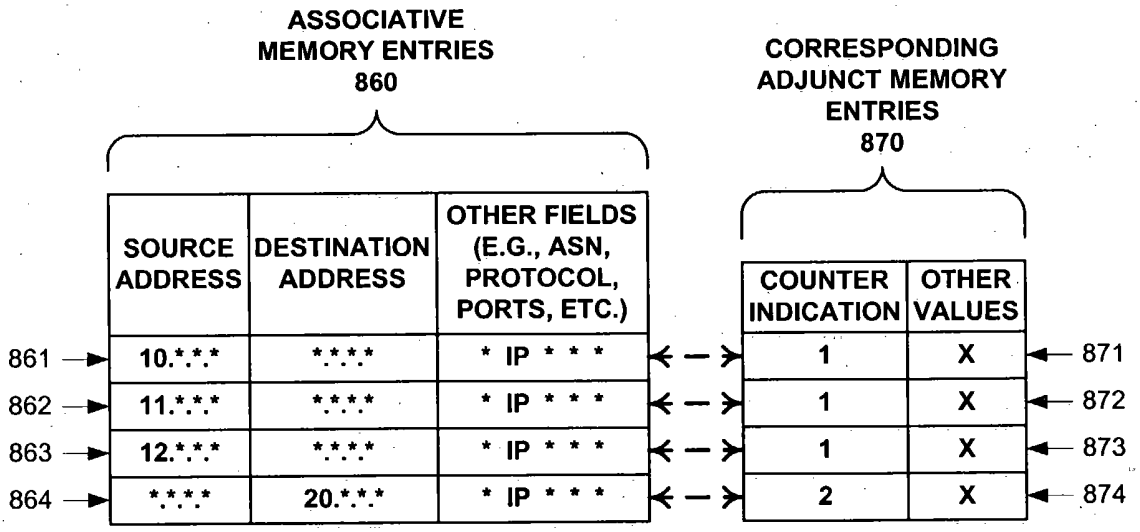

ASSOCIATIVE MEMORY ENTRIES 860
CORRESPONDING ADJUNCT MEMORY ENTRIES 870
SOURCE ADDRESS
DESTINATION ADDRESS
OTHER FIELDS (E.G., ASN, PROTOCOL, PORTS, ETC.)
COUNTER INDICATION
OTHER VALUES
861
862
863
864
10.*.*.*
11.*.*.*
12.*.*.*
..*.*
..*.*
..*.*
..*.*
20.*.*.*
* IP * * *
* IP * * *
* IP * * *
* IP * * *
1
1
1
2
X
X
X
X
871
872
873
874

FIGURE 8F

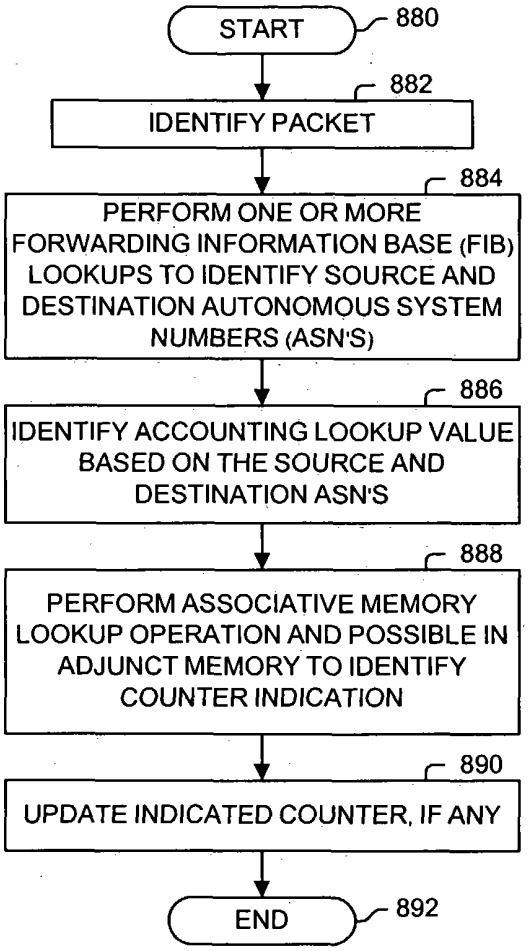

START
880
882
IDENTIFY PACKET
884
PERFORM ONE OR MORE FORWARDING INFORMATION BASE (FIB) LOOKUPS TO IDENTIFY SOURCE AND DESTINATION AUTONOMOUS SYSTEM NUMBERS (ASN'S)
886
IDENTIFY ACCOUNTING LOOKUP VALUE BASED ON THE SOURCE AND DESTINATION ASN'S
888
PERFORM ASSOCIATIVE MEMORY LOOKUP OPERATION AND POSSIBLE IN ADJUNCT MEMORY TO IDENTIFY COUNTER INDICATION
890
UPDATE INDICATED COUNTER, IF ANY
END
892

FIGURE 8G

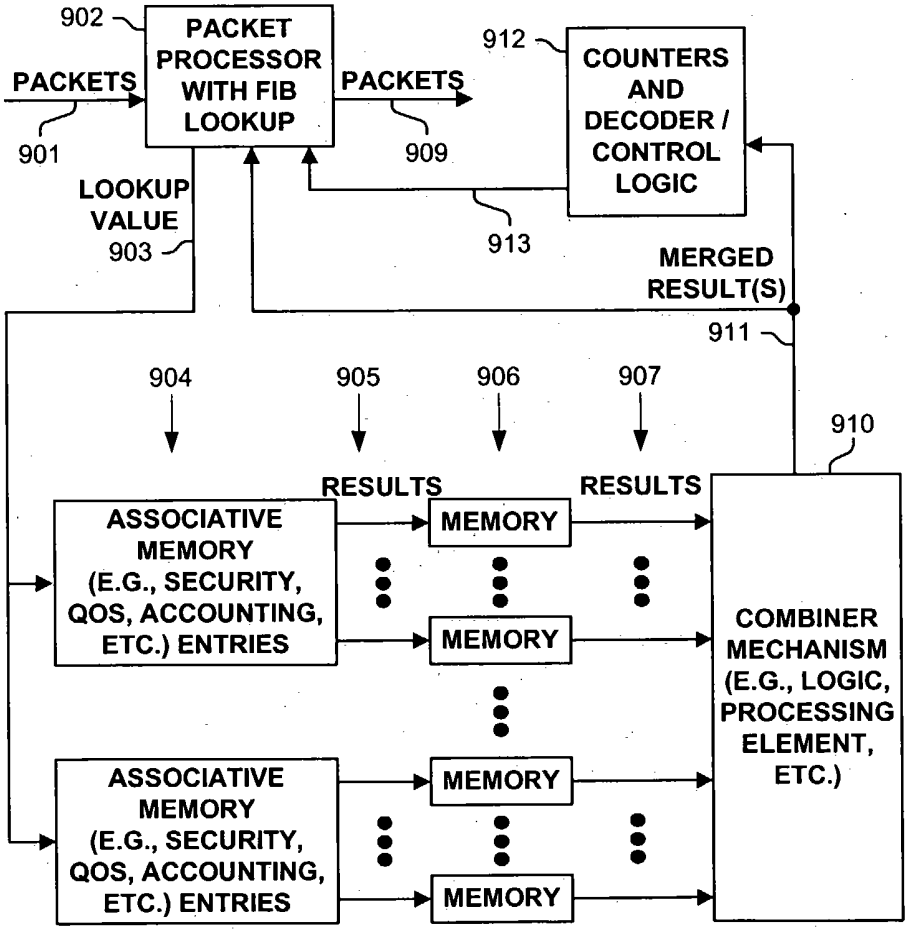

902
PACKET PROCESSOR WITH FIB LOOKUP
PACKETS
PACKETS
901
909
912
COUNTERS AND DECODER / CONTROL LOGIC
LOOKUP VALUE
903
913
MERGED RESULT(S)
911
904
905
906
907
910
RESULTS
RESULTS
ASSOCIATIVE MEMORY (E.G., SECURITY, QOS, ACCOUNTING, ETC.) ENTRIES
MEMORY
MEMORY
ASSOCIATIVE MEMORY (E.G., SECURITY, QOS, ACCOUNTING, ETC.) ENTRIES
MEMORY
MEMORY
COMBINER MECHANISM (E.G., LOGIC, PROCESSING ELEMENT, ETC.)

FIGURE 9A

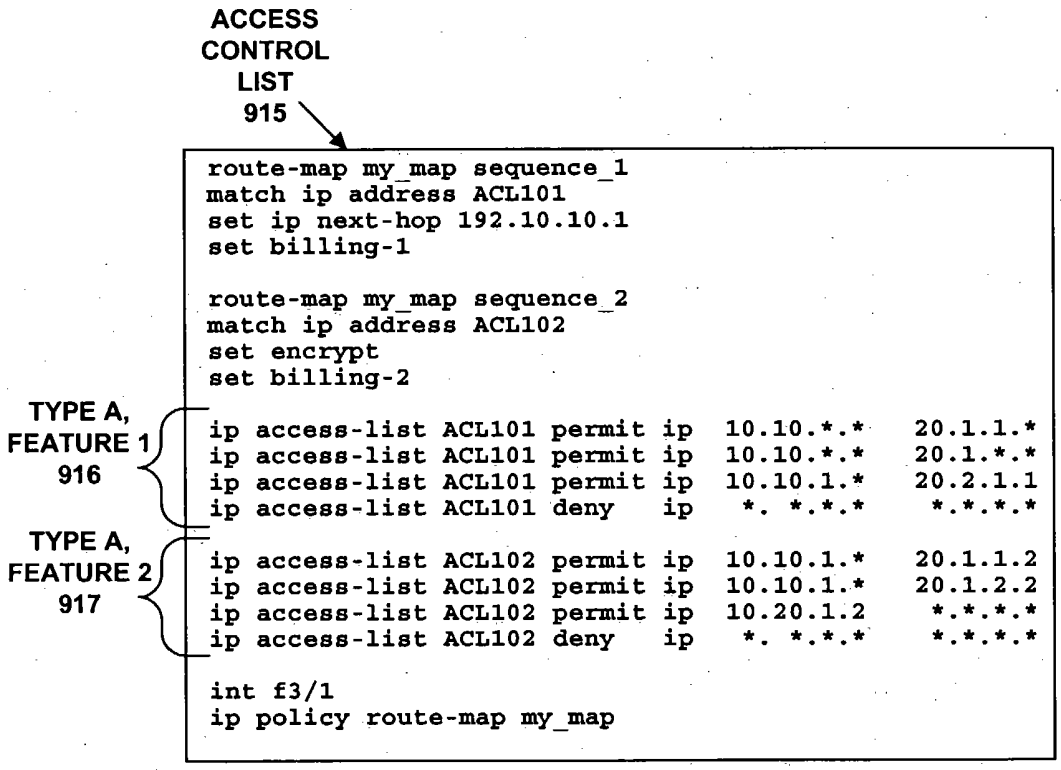

ACCESS CONTROL LIST 915
route-map my_map sequence_1
match ip address ACL101
set ip next-hop 192.10.10.1
set billing-1
route-map my_map sequence_2
match ip address ACL102
set encrypt
set billing-2
TYPE A, FEATURE 1 916
ip access-list ACL101 permit ip 10.10.*.* 20.1.1.*
ip access-list ACL101 permit ip 10.10.*.* 20.1.*.*
ip access-list ACL101 permit ip 10.10.1.* 20.2.1.1
ip access-list ACL101 deny ip *. *.*.* *.*.*.*
TYPE A, FEATURE 2 917
ip access-list ACL102 permit ip 10.10.1.* 20.1.1.2
ip access-list ACL102 permit ip 10.10.1.* 20.1.2.2
ip access-list ACL102 permit ip 10.20.1.2 *.*.*.*
ip access-list ACL102 deny ip *. *.*.* *.*.*.*
int f3/1
ip policy route-map my_map

FIGURE 9B

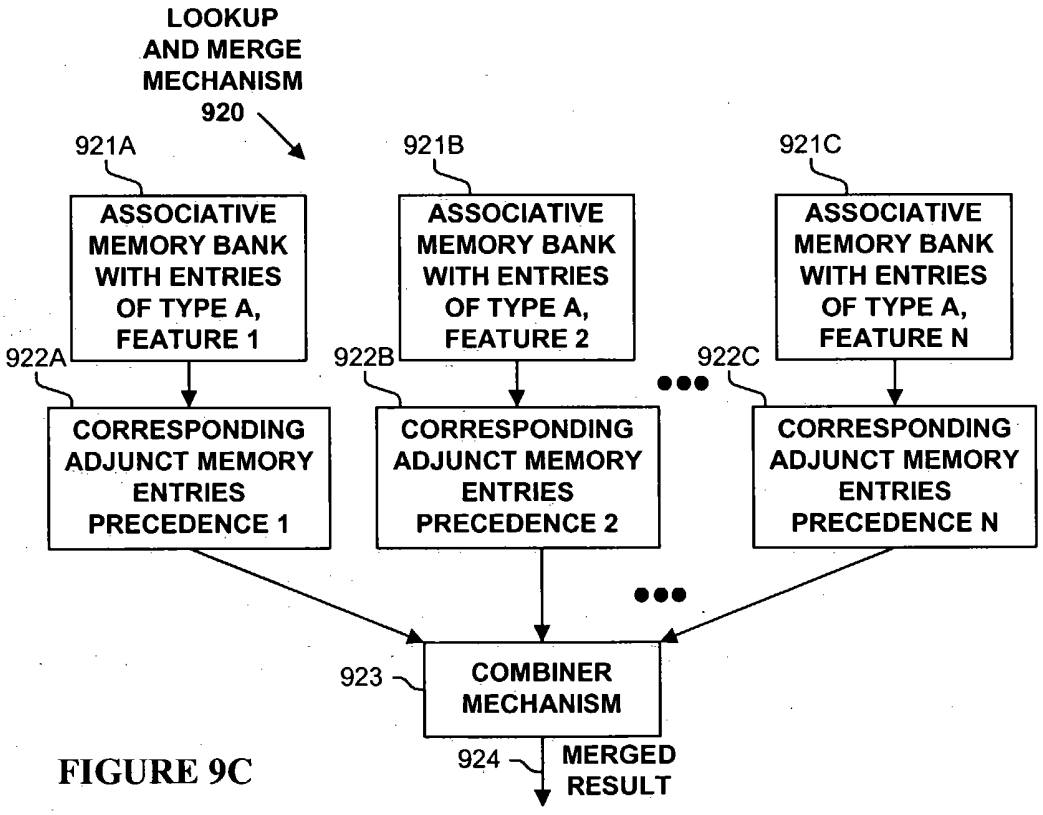

LOOKUP AND MERGE MECHANISM 920
921A
ASSOCIATIVE MEMORY BANK WITH ENTRIES OF TYPE A, FEATURE 1
921B
ASSOCIATIVE MEMORY BANK WITH ENTRIES OF TYPE A, FEATURE 2
921C
ASSOCIATIVE MEMORY BANK WITH ENTRIES OF TYPE A, FEATURE N
922A
CORRESPONDING ADJUNCT MEMORY ENTRIES PRECEDENCE 1
922B
CORRESPONDING ADJUNCT MEMORY ENTRIES PRECEDENCE 2
922C
CORRESPONDING ADJUNCT MEMORY ENTRIES PRECEDENCE N
923
COMBINER MECHANISM
924
MERGED RESULT

FIGURE 9C

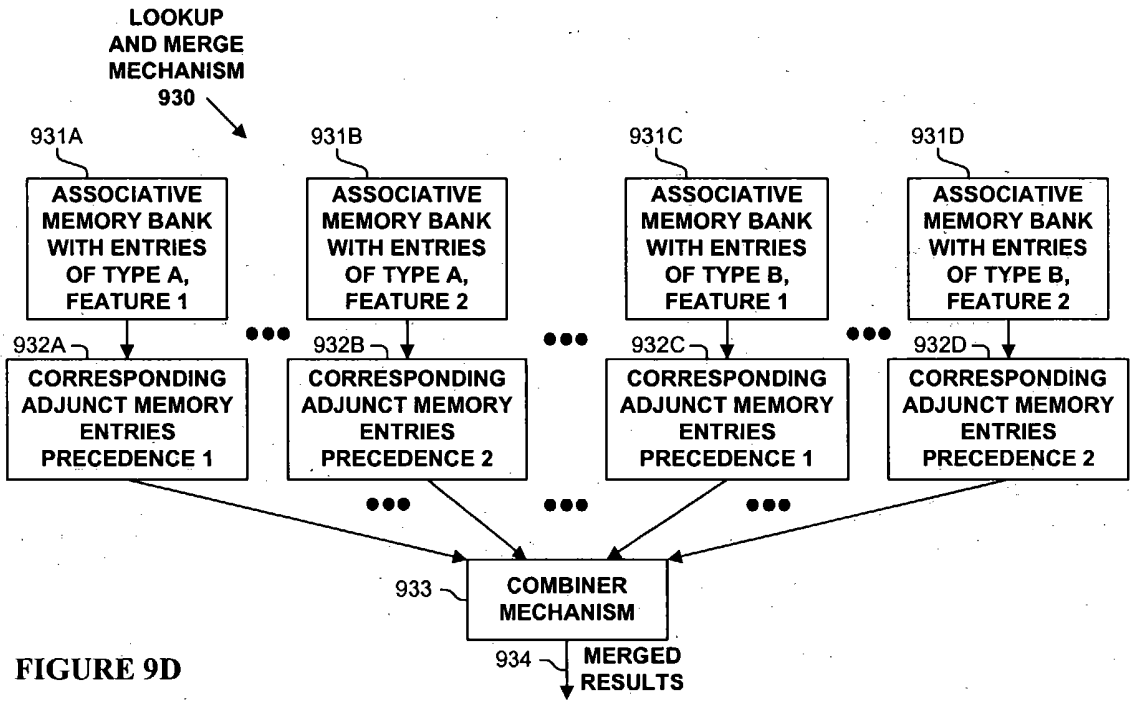

LOOKUP AND MERGE MECHANISM 930
931A
931B
931C
931D
ASSOCIATIVE MEMORY BANK WITH ENTRIES OF TYPE A, FEATURE 1
ASSOCIATIVE MEMORY BANK WITH ENTRIES OF TYPE A, FEATURE 2
ASSOCIATIVE MEMORY BANK WITH ENTRIES OF TYPE B, FEATURE 1
ASSOCIATIVE MEMORY BANK WITH ENTRIES OF TYPE B, FEATURE 2
932A
932B
932C
932D
CORRESPONDING ADJUNCT MEMORY ENTRIES PRECEDENCE 1
CORRESPONDING ADJUNCT MEMORY ENTRIES PRECEDENCE 2
CORRESPONDING ADJUNCT MEMORY ENTRIES PRECEDENCE 1
CORRESPONDING ADJUNCT MEMORY ENTRIES PRECEDENCE 2
933
COMBINER MECHANISM
934
MERGED RESULTS

FIGURE 9D

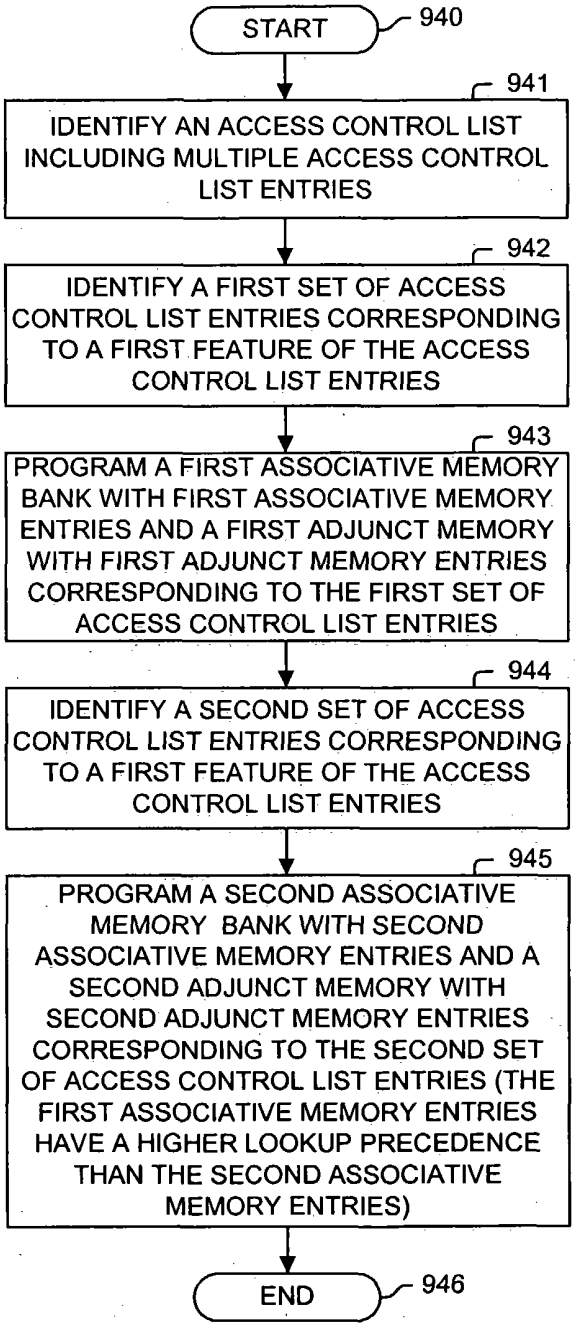

START
940
941
IDENTIFY AN ACCESS CONTROL LIST INCLUDING MULTIPLE ACCESS CONTROL LIST ENTRIES
942
IDENTIFY A FIRST SET OF ACCESS CONTROL LIST ENTRIES CORRESPONDING TO A FIRST FEATURE OF THE ACCESS CONTROL LIST ENTRIES
943
PROGRAM A FIRST ASSOCIATIVE MEMORY BANK WITH FIRST ASSOCIATIVE MEMORY ENTRIES AND A FIRST ADJUNCT MEMORY WITH FIRST ADJUNCT MEMORY ENTRIES CORRESPONDING TO THE FIRST SET OF ACCESS CONTROL LIST ENTRIES
944
IDENTIFY A SECOND SET OF ACCESS CONTROL LIST ENTRIES CORRESPONDING TO A FIRST FEATURE OF THE ACCESS CONTROL LIST ENTRIES
945
PROGRAM A SECOND ASSOCIATIVE MEMORY BANK WITH SECOND ASSOCIATIVE MEMORY ENTRIES AND A SECOND ADJUNCT MEMORY WITH SECOND ADJUNCT MEMORY ENTRIES CORRESPONDING TO THE SECOND SET OF ACCESS CONTROL LIST ENTRIES (THE FIRST ASSOCIATIVE MEMORY ENTRIES HAVE A HIGHER LOOKUP PRECEDENCE THAN THE SECOND ASSOCIATIVE MEMORY ENTRIES)
END
946

FIGURE 9E

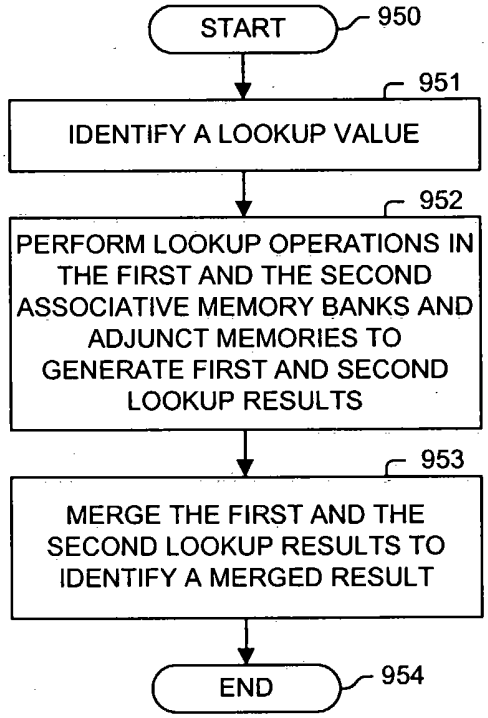

START
950
951
IDENTIFY A LOOKUP VALUE
952
PERFORM LOOKUP OPERATIONS IN THE FIRST AND THE SECOND ASSOCIATIVE MEMORY BANKS AND ADJUNCT MEMORIES TO GENERATE FIRST AND SECOND LOOKUP RESULTS
953
MERGE THE FIRST AND THE SECOND LOOKUP RESULTS TO IDENTIFY A MERGED RESULT
END
954

FIGURE 9F

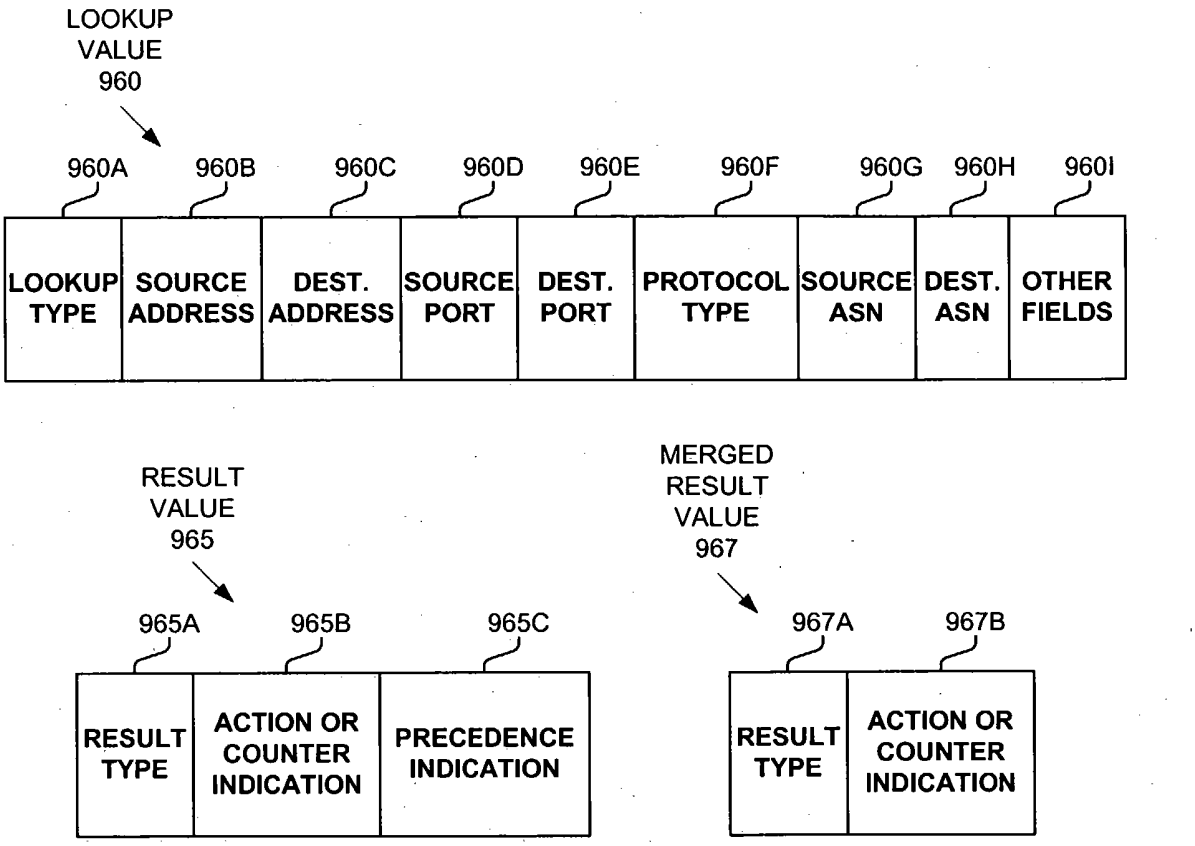
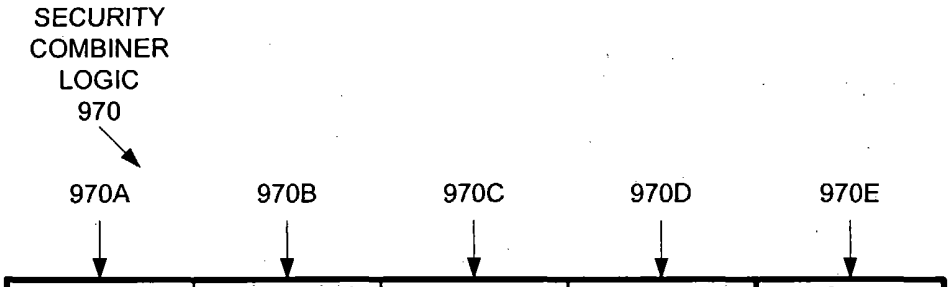
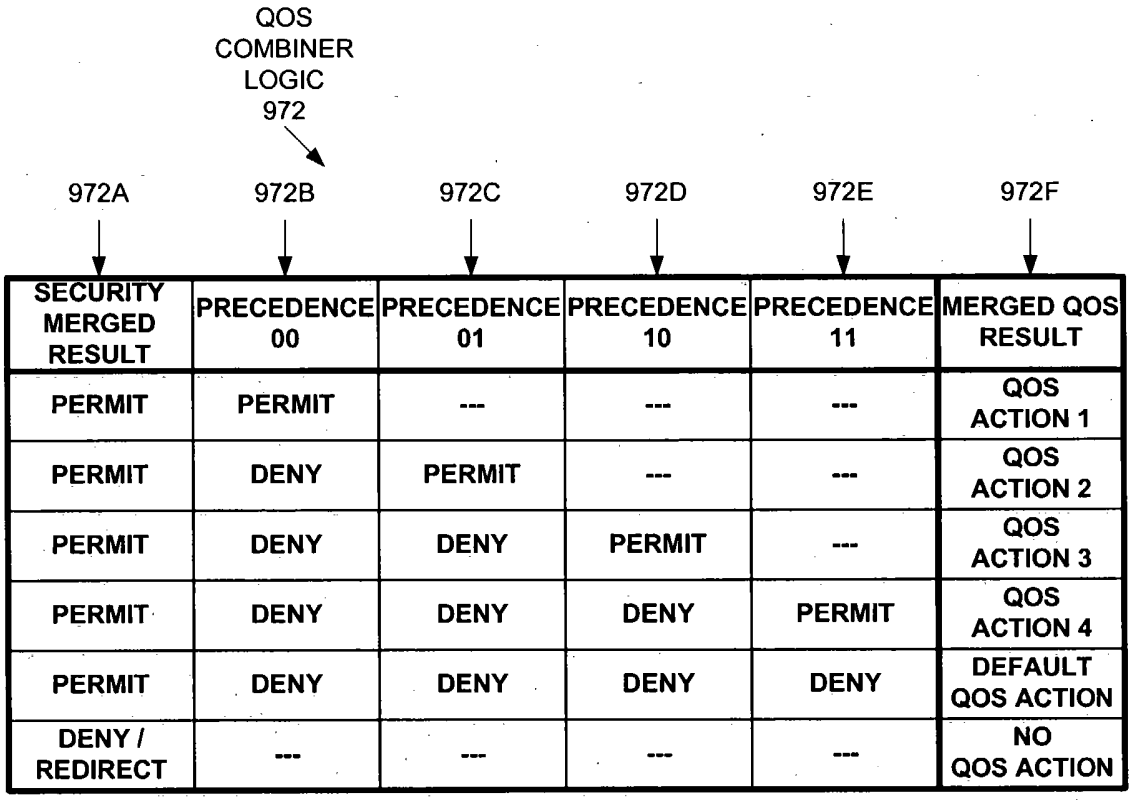

LOOKUP VALUE 960
960A
960B
960C
960D
960E
960F
960G
960H
960I
LOOKUP TYPE
SOURCE ADDRESS
DEST. ADDRESS
SOURCE PORT
DEST. PORT
PROTOCOL TYPE
SOURCE ASN
DEST. ASN
OTHER FIELDS
RESULT VALUE 965
965A
965B
965C
RESULT TYPE
ACTION OR COUNTER INDICATION
PRECEDENCE INDICATION
MERGED RESULT VALUE 967
967A
967B
RESULT TYPE
ACTION OR COUNTER INDICATION

FIGURE 9G



PRECEDENCE 00	PRECEDENCE 01	PRECEDENCE 10	PRECEDENCE 11	MERGED ACL RESULT
DENY	---	---	---	DROP
REDIRECT	---	---	---	REDIRECT
PERMIT	REDIRECT	---	---	REDIRECT
PERMIT	PERMIT	REDIRECT	---	REDIRECT
PERMIT	PERMIT	PERMIT	REDIRECT	REDIRECT
PERMIT	PERMIT	PERMIT	PERMIT	PERMIT
PERMIT	DENY	---	---	DROP
PERMIT	PERMIT	DENY	---	DROP
PERMIT	PERMIT	PERMIT	DENY	DROP

FIGURE 9H



SECURITY MERGED RESULT	PRECEDENCE 00	PRECEDENCE 01	PRECEDENCE 10	PRECEDENCE 11	MERGED QOS RESULT
PERMIT	PERMIT	---	---	---	QOS ACTION 1
PERMIT	DENY	PERMIT	---	---	QOS ACTION 2
PERMIT	DENY	DENY	PERMIT	---	QOS ACTION 3
PERMIT	DENY	DENY	DENY	PERMIT	QOS ACTION 4
PERMIT	DENY	DENY	DENY	DENY	DEFAULT QOS ACTION
DENY / REDIRECT	---	---	---	---	NO QOS ACTION

FIGURE 9I

ACCOUNTING COMBINER LOGIC 974

974A	974B	974C	974D	974E	974F
SECURITY MERGED RESULT	PRECEDENCE 00	PRECEDENCE 01	PRECEDENCE 10	PRECEDENCE 11	MERGED ACCOUNTING RESULT
PERMIT / REDIRECT	PERMIT	---	---	---	COUNTER ACTION 1
PERMIT / REDIRECT	DENY	PERMIT	---	---	COUNTER ACTION 2
PERMIT / REDIRECT	DENY	DENY	PERMIT	---	COUNTER ACTION 3
PERMIT / REDIRECT	DENY	DENY	DENY	PERMIT	COUNTER ACTION 4
PERMIT / REDIRECT	DENY	DENY	DENY	DENY	DEFAULT COUNTER ACTION
DENY	---	---	---	---	NO COUNTER ACTION

FIGURE 9J

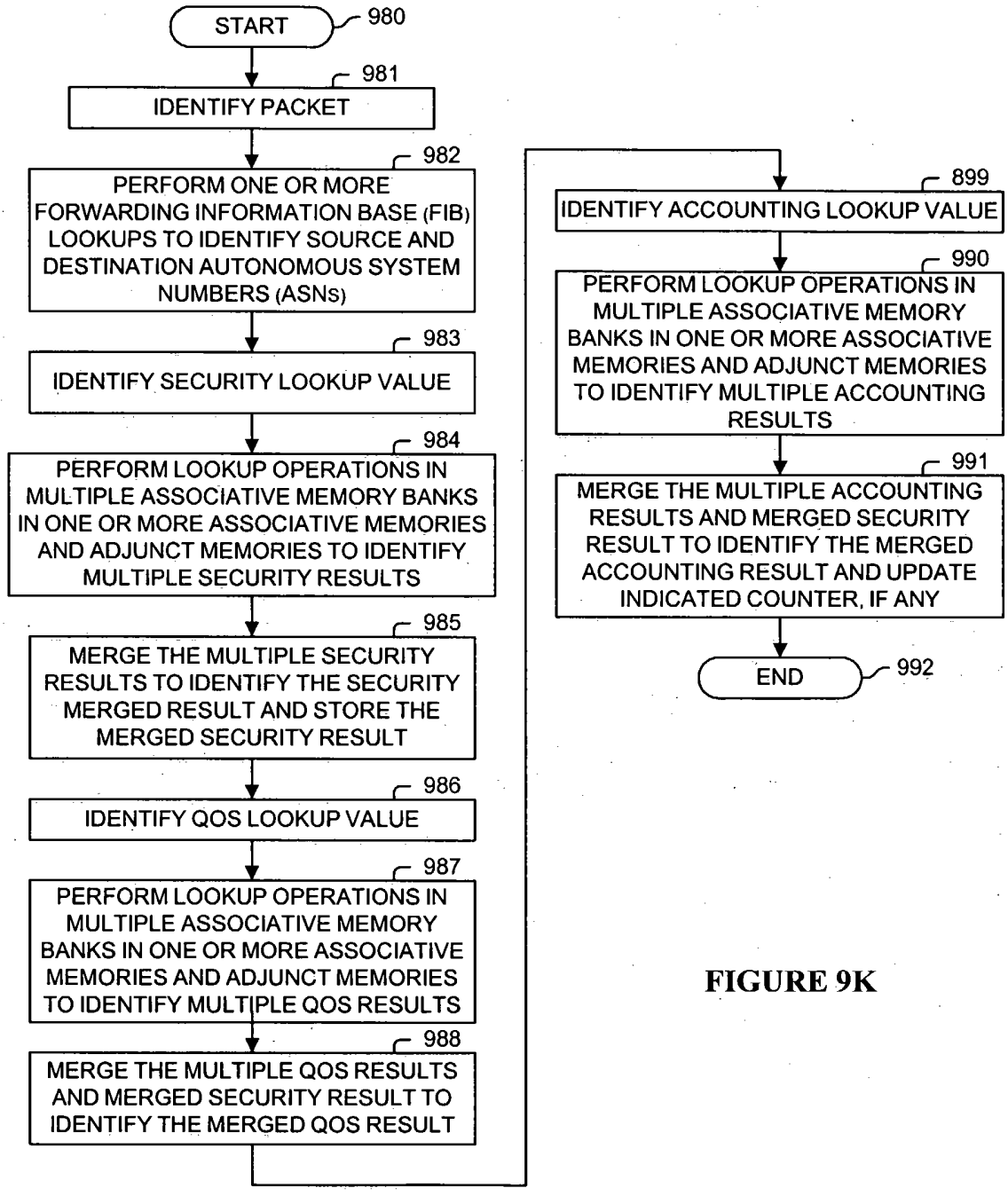

START
980
IDENTIFY PACKET
981
PERFORM ONE OR MORE FORWARDING INFORMATION BASE (FIB) LOOKUPS TO IDENTIFY SOURCE AND DESTINATION AUTONOMOUS SYSTEM NUMBERS (ASNs)
982
IDENTIFY SECURITY LOOKUP VALUE
983
PERFORM LOOKUP OPERATIONS IN MULTIPLE ASSOCIATIVE MEMORY BANKS IN ONE OR MORE ASSOCIATIVE MEMORIES AND ADJUNCT MEMORIES TO IDENTIFY MULTIPLE SECURITY RESULTS
984
MERGE THE MULTIPLE SECURITY RESULTS TO IDENTIFY THE SECURITY MERGED RESULT AND STORE THE MERGED SECURITY RESULT
985
IDENTIFY QOS LOOKUP VALUE
986
PERFORM LOOKUP OPERATIONS IN MULTIPLE ASSOCIATIVE MEMORY BANKS IN ONE OR MORE ASSOCIATIVE MEMORIES AND ADJUNCT MEMORIES TO IDENTIFY MULTIPLE QOS RESULTS
987
MERGE THE MULTIPLE QOS RESULTS AND MERGED SECURITY RESULT TO IDENTIFY THE MERGED QOS RESULT
988
IDENTIFY ACCOUNTING LOOKUP VALUE
899
PERFORM LOOKUP OPERATIONS IN MULTIPLE ASSOCIATIVE MEMORY BANKS IN ONE OR MORE ASSOCIATIVE MEMORIES AND ADJUNCT MEMORIES TO IDENTIFY MULTIPLE ACCOUNTING RESULTS
990
MERGE THE MULTIPLE ACCOUNTING RESULTS AND MERGED SECURITY RESULT TO IDENTIFY THE MERGED ACCOUNTING RESULT AND UPDATE INDICATED COUNTER, IF ANY
991
END
992

FIGURE 9K